<Chapter 1> Transboundary Environmental Pollution and Cooperation between Japan and China: A Historical Review

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Summary

This chapter makes a history review on disparity in concerns and cooperation for transboundary environmental pollution between China and Japan. China has placed high priority on economic growth and energy security, but the structural problems of a heavy reliance on coal, inefficient energy production and consumption, and increasing energy consumption does not allow China to take effective measures to reduce SO_2 emissions, let alone transboundary acid rain and greenhouse gas (GHG) emissions.

Japan, on the other hand, used to be mainly concerned about transboundary acid rain and provided environmental assistance in support of air pollution control projects, but failed to change China's attitude. Since the Third Conference of Parties for United Nations Framework Convention on Climate Change (UNFCCC), a reduction in GHGs has been given a higher policy priority. Japan also requires emerging countries to establish some reduction targets in order that they do not offset the emission reduction activities of Annex I countries.

However, rising global concerns over climate change increases expectation that the CDM can be a tool for reducing this disparity and encouraging environmental cooperation. China recognizes that the CDM can be a useful tool for attaining diplomatic and economic goals, and has modified its stance to actively utilize the CDM to maximize its benefit. Japan has become active in finding prominent Clean Development Mechanism (CDM) and Joint Implementation (JI) projects as a cost-effective means to attain the GHG reduction target.

Key words

Environmental cooperation, SO2, ODA, GHG, CDM

1-1 Introduction

China has rapidly increased greenhouse gas (GHG) emissions in the process of high-speed economic growth. China became the largest emitter in the world in 2007, followed by the United State, Russia, India, the EU and Japan (Figure 1-1). Under the United Nations Framework Convention on Climate Change (UNFCCC), GHG emission reduction targets were established for Annex I countries including the US, the EU, Japan and Russia. The EU, Japan and Russia signed the Kyoto Protocol and accepted their reduction target while the US has not. On the other hand, non-Annex I countries have been given no reduction obligations despite their rapid increase in GHG emissions over recent years. China's emissions have increased considerably, and it is expected to surpass the US as the world's largest emitter of GHGs in the coming decades.

China's policy priority, however, is economic growth, and it is only concerned with environmental issues where they constrain that growth. By contrast, Japan had been concerned about transboundary acid rain problems and provided environmental aid to reduce sulfur emission in China. However, when China changed its focus toward reducing sulfur emissions, Japan changed its policy priority toward GHGs and is now more concerned with reducing GHG emissions in China in pursuit of certified emission reductions (CERs).

This chapter examines history of energy and transboundary environmental policies in China and Japan, and clarifies how CDM has offered opportunity for environmental cooperation between them.

1-2 Energy and environmental policies in China

Given the level of national poverty before the 1980s, China made economic development its highest priority under the Reform and Open-door Policy. As economic growth accelerated, serious energy shortages occurred, with most cities experiencing episodic brownouts or rotating blackouts, resulting in underutilized industrial capacity. Recognizing that energy security is indispensable for sustaining economic growth, the Chinese government prioritized the enhancement of energy supply capacity.

To increase energy supply, the government began to implement institutional reforms in the 1980s. It abandoned the state's monopoly on energy supply and allowed regional and corporate entities and joint ventures to enter into the production market. China's State Council promulgated the "Provisional Regulations on

Promoting Fund-Raising for Investment in the Power Sector and Implementing Different Power Prices" in 1985 in order to encourage independent power producers (IPPs), including foreign economic entities, to enter into the power generation market under long-term contracts. This encouraged township and village enterprises (TVEs) to actively invest in coal mining and production (Horii, 2000). The regulation also provided guidelines for raising investment funds for the power sector so that the state could reduce its share of financing capital costs (Feng, 2003). A new pricing policy was also implemented for power generated from newly built power plants. Under this policy, prices were determined by cost-plus principle. This guaranteed IPPs sufficient profits by allowing them sell the power at a price that could recover capital and operational costs over a relatively short term, generally within ten years, regardless of efficiency (Li et al., 2003). Hence, this policy provided a good incentive to invest in coal-fired thermal power generation, and this, along with other efforts, resolved the power shortage problem by the mid-1990s.

Regardless of these efforts, China's energy sector could not overcome the tradeoff between expansion of supply capacity on the one hand, and a structurally heavy reliance on coal and its inefficient use on the other (Hatch, 2003). The share of coal used for power generation in China was 96% in the 1950s and 88% in the 1960s. Although this share dropped to 70-76% by the 1980s, China remains the biggest consumer of coal in the world because total production has continued to increase (Figure 1-2). This predominance of coal is principally a function of the large indigenous deposits, but government policy to increase the capacity of thermal power plants has also increased China's reliance on coal. The Ministry of Water Resources and Electric Power (MWREP) preferred to construct thermal plants instead of hydroelectric ones, and smaller hydropower stations over larger ones due to advantages of cost and time savings. Thermal power plants were less expensive to construct, came on line more quickly, and output was more reliable and easily controlled than either nuclear or hydropower plants. Moreover, prices for electric power did not accurately reflect either cost of production or the real mix of resources available for generation in each region (Lieberthal and Oksenberg, 1988: 102). The government also promoted the substitution of coal in place of crude oil as the fuel used in thermal power plants, for the latter could be exported to bring in scarce hard foreign currency. As a result, electric power supplied from coal-fired thermal power plants has increased tremendously, and accordingly the share of coal in energy supply has increased substantially since the 1980s.

This capacity enhancement policy led to an increase in the number of small and inefficient coal-fired thermal power plants. By the end of the 1980s, the share of thermal power in total power generation plants with less than a 100MW capacity was over 40%. Although this share has been shrinking, overall capacity had doubled by 2003 (Table 1-1). The average size of thermal power plants has generally been very small, and their efficiency rate less than three-fourths compared with those in Japan (Michaelowa et al., 2003). China's inefficient use of energy can be explained by its reliance on the industrial sector, especially heavy industries. Given the military containment policy of the US and the USSR alongside the limited availability of imported capital and technologies, China had no choice but to create heavy industries for the purpose of national security. The energy and resource intensity of these industries is higher than that of other industries, and by the 1990s, three sub-sectors of heavy industry—chemicals, nonmetal minerals, and smelting and pressing of ferrous metals—shared over 40% of energy consumption.

Low levels of energy efficiency have been prevalent throughout various sectors. Most industrial boilers were small, with an efficiency of around 50-60%, and millions of coal-fired household stoves had a 10-15% efficiency rate, compared with 80-95% for natural gas (Hatch, 2003). In addition, energy and electricity prices in the centrally planned economy were set at a low level, which increased demand and consumption, and acted as a disincentive for conservation.

Increased reliance on coal and inefficient use of energy has led to serious environmental problems, especially air pollution. Dust and SO_2 emissions have increased, although the former decreased in the mid-1990s. Among various sources, the industrial sector has discharged the largest amount of SO_2, followed by the residential sector. Within the industrial sector, electric power has the largest share, followed by non-metal, chemical, ferrous and non-ferrous metals. The share, as well as emission volume of the power sector, has recently grown even larger (Figure 1-3). This suggests that small inefficient power plants that use coals with a high sulfur content have been operating amid the recent rapid economic growth.

The World Bank (1997) estimated that, in 1995, domestic pollution from SO_2 emissions in China caused economic damage of RMB 352.5 billion from dry deposition and 41.4 billion from wet deposition, and the total amounted to 7.1% of gross domestic product (GDP) (Table 1-2). Although estimated results vary by researcher, such economic damage, along with a widening income gap, have potentially produced social unrest.

When it became apparent in the late 1990s that the power shortage problem had been resolved, and that there was an oversupply of coal, China once more began to implement institutional reforms in the energy sector in order to improve energy efficiency and reduce environmental damage. The government began to remove energy subsidies in order to slow demand, and also forced the closure of more than thirty thousand small and inefficient coal mining during 1998-2000. This resulted in a sharp drop in coal production and in the share of coal for power production, although small mining operations were said to have continued illegally (Figure 1-2). It also forcefully shut down small power plants with a capacity of less than 50MW.

In the power sector, revision of the Electricity Law in 1996 separated the business function of the Ministry of Electric Power from the government/regulatory body. In 1997, the Ministry of Electric Power was abandoned completely and the State Power Corporation was created in its place. The goal was to separate utility business management from government oversight, and to establish independent utility entities. The former Ministry's governmental, or regulatory, responsibilities were allocated to the State Development and Planning Commission (SDPC) and State Economic and Trade Commission (SETC).

Air pollution control policy was enhanced during the Ninth Five-year Plan period (1996-2000). The National Environmental Protection Administration (NEPA) revised the Air Pollution Act in 1995 to introduce a total pollutants load control for several pollutants, such as black smoke, dust, and SO_2. It also designated SO_2 and acid rain control zones in 1998. During the Tenth Five-year Plan (2001-2005), the State Environmental Protection Administration (SEPA)[1] required all areas to cut emissions of designated pollutants by 10%, and the SO_2 and acid rain control zones to cut them by 20%. However, the NEPA lacks the financial resources to enforce these policies. It published the "Trans-Century Green Project Program" that listed pollution sources that had caused serious environmental degradation and environmental projects that should be urgently implemented. Through this program, it requested foreign governments and international development institutions to provide financial aid.

Since 2000, air pollution control policy has been strengthened. In 2003, the SEPA published regulations for coal-fired thermal power plants that required (a) the construction and expansion of coal-fired thermal power plants to be basically abandoned in the construction areas of large and medium-size cities, and (b) fuel-gas desulfurization (FGD) to be installed when construction or expansion of coal-fired thermal power plants occurred within the SO_2 and acid rain control areas. The central government also developed a natural gas pipeline from the Western region to the Eastern coastal areas. In 1992, in order to provide an economic incentive to reduce emissions, the SEPA created a pollutants levy that exclusively targeted SO_2; since then it has reformed the existing levy system gradually expanding its area and raising the tariff[2]. It began to charge the levy in proportion to the amount of emissions, regardless of compliance with emissions standards. The SEPA initiated a trial SO_2 emission trading program in several cities and provinces. Finally, in 2003, the government published the "Program of Action for Sustainable Development in China in the Early 21st Century" to highlight ecological protection, environmental protection, and pollution control as priority areas.

Despite these industrial reforms and implementations of environmental projects, reliance on coal has increased, energy use has become less efficient, and local air pollution has worsened following the rapid economic growth since 2002. Due to reduced investment in thermal power plants, many provinces suffered power shortages when faced with rapid increases in demand because generation capacity could not be expanded quickly enough. In the process of capacity development, locally owned power plants could be constructed easily without the need to install FGD systems and many small and inefficient plants may well have been constructed and started operating owing to local governments preferentially purchasing power from them, a lack of monitoring and enforcement of SO_2 emission control as well as cost advantages. This has led to the insufficient use of capacity of the State Power Company's larger thermal power plants (Horii, 2006). Overall, this has increased SO_2 emissions from power plants, and subsequently total sulfur emissions, which have surpassed the amount of 1995 (Table 1-3). Given the gradual improvement of air quality in the inner areas of the industrial cities, this implies that air pollution and its damage may have been displaced to the outskirts and rural areas.

The Eleventh Five-year Plan (2006-2010) emphasizes a change in pattern of economic growth toward a resource-efficient and environment-friendly society, requiring a reduction of 10% in SO_2 emissions and 20% in energy consumption. The SEPA began to require the coal mining industry to invest in safety in the work place, or otherwise be shut down. After legislation of the Environmental Impact Assessment (EIA) Act in 2003, the SEPA has often withheld approval for power plant construction, given orders to stop construction, and even to forcefully pull down partially constructed power plants in cases where it judged they did not comply with the requirements of the EIA. The SEPA expects these measures to provide a deterrent to install small inefficient coal mining and power plants.

However, it demands tremendous efforts to overcome the structural problems of a heavy reliance on coal, inefficient energy production and consumption, and increasing SO_2 emissions. On the one hand, the government continues to place priority on the security of energy supply to ensure sustainable economic growth. Only when projections are that electric power will be oversupplied in near future can the SEPA rigorously enforce the regulations. It is very unlikely that the SEPA will be allowed to continue stringent enforcement when China faces an energy shortage again. On the other hand, locally owned coal mining and power plants constitute an important source of income for local governments and provide an employment opportunity to local economies. Local governments have strong incentives to continue the operation of small coal mining and power plants, despite them being inefficient and heavy polluters, even when the central government wants them shut down. This local attitude has delayed the structural reform of the energy industry and the introduction of energy-efficient production technology. To attain the energy saving target in the 11th Five-Year Plan, the central government declared that it would take energy saving performance into serious consideration when evaluating leaders of local governments.

1-3 Environmental concerns in Japan

By the 1980s, Japan had reduced SO_2 emissions significantly by adopting several measures: (a) a switch to liquefied natural gas (LNG) as a fuel, (b) FGD installation, (c) energy conservation, (d) structural change of industries, and (e) a shift to nuclear power generation. However, it has suffered from damage caused by acid rain since the 1990s. Japanese people suspect that sulfur emissions from China have caused increased sulfur depositions and acid rain in Japan. However, scientific research has shown mixed results. Huang et al. (1994) claim that China's contribution was only 2% while Ikeda (1995) shows it amounts to 25% (Table 1-4). Calori et al. (2001) estimate that in 1990, Japanese anthropogenic emissions contributed almost 50% of total sulfur deposition while the contribution from China was 21%, whereas in 1995, the Japanese contribution declined to 38% while China's increased to 40%.

Due to Japan's growing concerns over transboundary acid rain, and alongside its technological advantage and a commitment to increase environmental official development assistance (ODA), the Japanese government has provided a huge amount of environmental ODA to reduce industrial and urban air pollution in North and Northeast China, where the sources of acid rain are deemed to be located. According to data of the Development Assistance Committee, Japan has provided China with US$ 10.2 billion of ODA for the environmental area during 1995-2004 [3]. Environmental ODA, as a share of total ODA, increased to 27.2% during 1996-2000, and to over 70% during 2000-2001. By sector, Japan has focused primarily on activities in the transportation and energy sectors [4], followed by water and sanitation, and flood protection. Japan has provided environmental aid to the power and energy sector mainly for thermal power plant renovation, installation of electric scrubbers and FGD systems, and increasing capacity of transmission and distribution. Such assistance directly or indirectly reduces SO_2 emissions by lowering transmission loss and raising energy efficiency. Japan has also provided financial aid to construct large-scale coal gas supply systems and district heating systems that enables local governments to replace a large number of small inefficient industrial boilers and coal-fired household stoves. It is estimated that by 2003, Japanese ODA assisted projects had reduced SO_2 emissions by 190,000 tons annually, which amounts to a 4.9% reduction that China realized through environmental policies during 1996-2003 (Mori, 2008a).

However, Japanese aid for SO_2 emission reduction in China faced several difficulties in implementation (Mori, 2008b). Some industrial pollution control assistance projects failed to attain their planned environmental performance amid industrial restructuring in the transitional period. Privatization makes it difficult to provide aid for industrial pollution control due to fear of criticism that such aid contradicts the polluter pays principle. Exploitation and transmission of natural gas from West China has made aid for coal gasification plant redundant. Rapid urbanization has forced industry to relocate to areas outside the cities and to install more efficient systems and reduction pollution, but relocation may make pollution control investment to the existing plants redundant when the government ordered abandon of the old plants.

This, together with a shift in its environmental ODA provision toward sewerage systems and reforestation and toward China’s rapid economic growth, resulted in disincentives for the Japanese government to continue environmental ODA to China. With recent strained diplomatic tensions, as symbolized by protests against Japan in April 2005, Japan and China agreed that Japan would terminate provision of ODA loans to China in 2008. Thus, environmental ODA is no longer a financial mechanism to promote air pollution control in China.

While Japan is now less concerned about transboundary acid rain problems, its concern over GHG emissions reduction has increased. This shift became apparent after 1997 when Japan, as an Annex I country, agreed at the third Conference of Parties (COP3) held in Kyoto, Japan to reduce GHG emissions by 6% in the first commitment period (2008-2012). Despite this agreement, Japan's CO_2 emissions increased to 1.355 billion tons in 2004, which amounts to 108% of the 1990's emission level. This means that Japan should reduce GHG emissions by 14% if it is to attain the Kyoto target.

In 1998, Japan enacted the "Outline for Promotion of Efforts to Prevent Global Warming" as a basic plan, but the Outline established no specific reduction actions, and thus no sanctions for noncompliance[5]. As a result, GHG emissions increased by 6.9% in 1999 when compared to the amount in 1990.

Japan revised the Outline in 2002 to conform with the rules agreed in the Marrakesh Accords, which, for example, required Annex I parties to use Kyoto flexible mechanisms as "supplemental to domestic action" (Decision15/CP.7)[6]. The Outline adjusted the measures proposed to attain the target and adopted a gas-by-gas approach. It specified a 2% reduction from innovative technological development and greater efforts on the part of citizens. It also adjusted the reduction by Kyoto flexible mechanisms to 1.6% from 1.8%.

Nonetheless, the 2002 Outline does not allocate a reduction target to each sector or firm, thus effective measurement and enforcement of reductions is not possible. The volume of GHG emissions has remained more or less the same over the past few years. Demand for cheap energy such as coal is increasing, despite its higher GHG emission impact[7].

To enhance the effectiveness of the 2002 Outline, the Cabinet decided to adopt the Kyoto Protocol Target Achievement Plan in 2005. The Plan consists of additional domestic measures, absorption by sinks and other means, and utilization of Kyoto flexible mechanisms; these are expected to reduce GHG emissions by 6.5%, 3.9%, and 1.6% respectively. To further domestic measures, the Ministry of the Environment proposed a carbon tax and implemented a pilot emissions trading, but in vain due to fierce opposition from industries. This forces the government to rely more on the Kyoto flexible mechanisms.

Among the Kyoto flexible mechanisms, Japan has prepared and employed the CDM more often than JI and the Emission Trading Scheme (ETS). The New Energy and Industrial Technology Development Organization (NEDO) has assisted capacity building for the CDM since 2003. The Japan Kyoto Mechanism Acceleration Program was established in 2004 to support potential and actual CDM projects both technically and financially. In response, Japanese entities have since proposed and implemented many CDM projects. Up to November 2008, the Japanese government has approved 408 CDM projects of which 108 have already been approved by the CDM Executive Board.

Soon after the Democracy Party of Japan had taken over the government, the prime minister pledged to cut GHG emissions by 25% by 2020 from 1990 levels at the UN Climate Change Summit in 2009, on the condition that major emitters, such as the United States and china would make a significant reduction. To achieve this "ambitious" target, the government prepared the Climate Change Bill that stipulates adoption of policies and measures such as emission trading scheme, carbon tax, and feed-in-tariff for renewable energy. However, it is suspected that Japan can attain this target only by domestic measures. Kyoto flexible mechanisms will continue to play an essential role in this regard.

1-4 China's CDM strategy and climate change policy

China has long been skeptical about climate change, and has not been active in international negotiations. It has not formulated any policies specific to climate change, although policies aimed at SO_2 emissions and acid rain control might have unintentionally resulted in a GHG reduction. Recently, it has formulated energy saving policies and established a renewable energy development strategy, but did so only in response to the recent surge in oil price and subsequent international concern over China's active resource extraction around the world.

Only after the structures of the Kyoto mechanisms evolved and understanding of the mechanisms and their potential benefits to China became clear, did it become less skeptical and more receptive toward climate change, and especially the CDM. China perceives the CDM as a measure to help it attain economic and diplomatic goals. It also recognizes that the CDM will bring large amounts of windfall finance and advanced technologies to China. As the World Bank et al. (2004) show, the CDM is expected to bring to China such potential benefits as (a) net foreign investment, up to $475 million, (b) higher rates of efficiency improvement in energy end-use and electricity generation, (c) a 0.5% annual GDP increase through investment and localization of advanced technologies, (d) local economic development through technology transfers and tax revenue, and (e) resource efficiency, through the use of waste for energy generation and more efficient use of energy.

This indicates that the CDM may provide China with an opportunity to sustain economic growth without an increasing reliance on coal and inefficient energy use, and thus may create room for changing the aforementioned tradeoff between increases in energy supply capacity on the one hand, and a greater reliance on coal and less efficient use on the other. Development of renewable energy enables the government to respond to growing electric power demand while still reducing coal consumption. Transfer, localization, and diffusion of advanced technologies may enhance energy efficiency, save energy, and lead to a reduction in coal consumption.

This expectation, along with other economic and diplomatic motivations, has prompted China to stimulate as many CDM projects. It published the "Measures for Operation and Management of Clean Development Mechanism Projects in China" in 2005, and to formulate the China's National Climate Change Programme in 2007 that outlines objectives, basic principles, key areas of actions, as well as policies and measures to address climate change for the period up to 2010. To obtain the maximum benefit from CDM projects, the Measure stipulates that the government of China and the project owner should jointly own the revenue from the transfer of CERs, and Chinese entities should have more than half of the stake of the project owner. Moreover, it designates that energy efficiency improvement, development and utilization of new and renewable energy, and methane recovery and utilization as preferred types of projects in order to attract foreign investments to these fields.

Still, China avoids making international commitment to the reduction of GHG emissions. China still has large number of poor farmers. Despite of the reduction of absolute poverty, income gap has been widened between East and West, and urban and rural areas. The government recognizes that economic growth and urbanization is indispensable to mitigate poor peoples' discontent with the widening income gap. This recognition, along with its leading position of developing countries in the international negotiation, made China oppose to the GHG reduction on the name of "common but differentiated responsibility."

International society gradually recognized China's this attitude as barriers to the post-2012 climate regime. It raised concern about tariff adjustment measures to imports from non-commitment countries, reasoning that the latter could dump the climate mitigation cost to increase exports.

To take the balance, Chinese government finally published climate change policies as a domestic commitment at the United Nations Conference on Climate Change in September 2009 and then committed to reduce GHG emissions by 40-45% per GDP by 2020. To achieve the remarkable progress, it made a draft bill on climate change in 2010.

1-5 Conclusion

This chapter makes historical review over the priority of transboundary environmental pollution and shows the between China and Japan. China has placed high priority on economic growth and energy security, but the structural problems of a heavy reliance on coal, inefficient energy production and consumption, and increasing emission of SO_2 do not allow it to take effective measures on SO_2 emission reduction, let alone transboundary acid rain and GHG emission reduction.

Japan, on the other hand, used to be highly concerned about transboundary acid rain, and provided huge amount of environmental assistance to China in support of air pollution control projects. However, Japan reduced this aid due to China's shift of focus toward other environmental problems, its own toward GHG emission reductions, its tight fiscal constraints and less support from Japanese citizens over government assistance to China. On the other hand, it became active in finding prominent CDM and JI projects as a cost-effective means to attain GHG emission reduction targets, considering the higher marginal costs required for Japanese domestic GHG emission reduction measures. This action is stimulated by the political change in 2009 that followed by the international commitment on a 25% reduction of GHG emissions by 1990 level. Japan also requires a few developing countries to establish some reduction targets in order that they do not offset the emission reduction activities of Annex I countries.

After having recognized that the CDM could be used as a tool to attain diplomatic and economic goals, China modified its attitude to actively utilize the CDM to maximize its own benefits. Though China maintains an opposition to reduction target setting for developing countries, this adjustment in attitude is expected to enhance mutual cooperation between China and Japan for mitigating transboundary environmental problems.

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1 NEPA was reorganized into SEPA in the 1998 bureaucrat reorganization. Ranking of the minister was upgraded while the ministry lost its key coordinating function.

2 The SO_2 levy was introduced at a rate of RMB 0.20/kg in 1992 in Guangzhou and in eight other cities where there was serious acid rain. In 1998, the levy was extended to the SO_2 and acid rain control zones. The rate was raised to RMB 0.6/kg for three trial cities: Jilin, Hangzhou and Zhengzhou. This rate was extended to cover the entire country in 2003.

3 DAC defines an activity as environmental-oriented, thus environmental ODA if an activity is intended to produce an improvement, or something that is determined as an improvement, in the physical and/or biological environment of the recipient country, area or target group concerned, or if it includes specific actions to integrate environmental concerns with a range of development objectives through institutional building and/or capacity development (DCD/DAC/ENV96(14)). According to this definition, economic infrastructure and services, such as activities promoting sustainable use of energy resources as well as social ones, and sustainable natural resource management are classified as environmental-oriented activity.

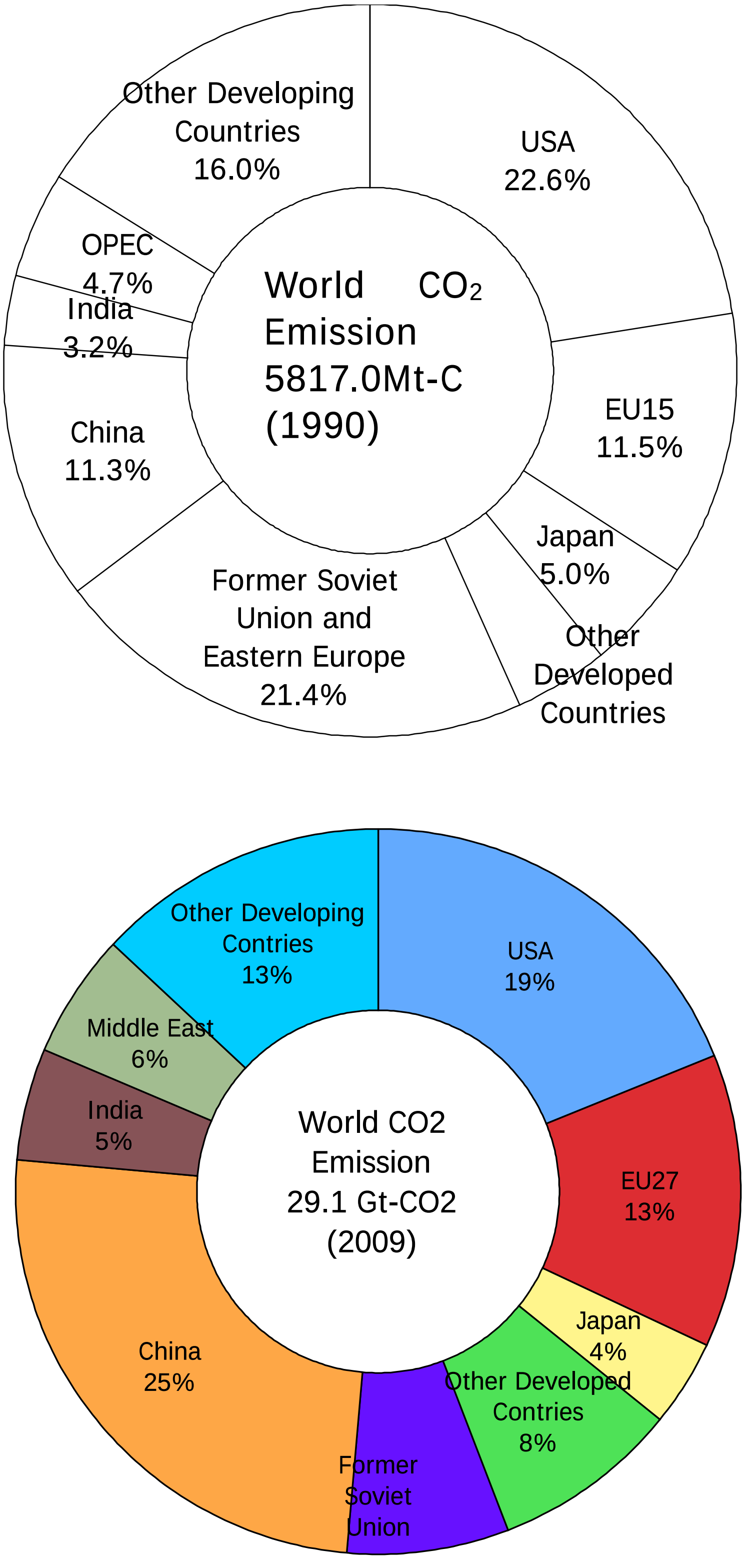
4 Activities in the energy sector include rehabilitation of thermal power plants and transmission and distribution systems as well as investment in small hydropower plants and renewable energy.

5 See Ministry of Environment, Japan, 2003, “Concerning GHG Emission in 2002”.

6 The Kyoto Protocol also requires supplementary of international emissions trading (article 17) and joint implementation (article 6.1(d)). With regards to the CDM (article 12.3(b)), supplementary is described as being when certified emissions reductions (CER) “contribute to compliance with part of their quantified emission limitation and reduction commitments”. Correspondingly, the Marrakech Accord has no quantified goal for usage of Kyoto flexible mechanisms, but assesses some constraint of supplementary in relation to domestic action.

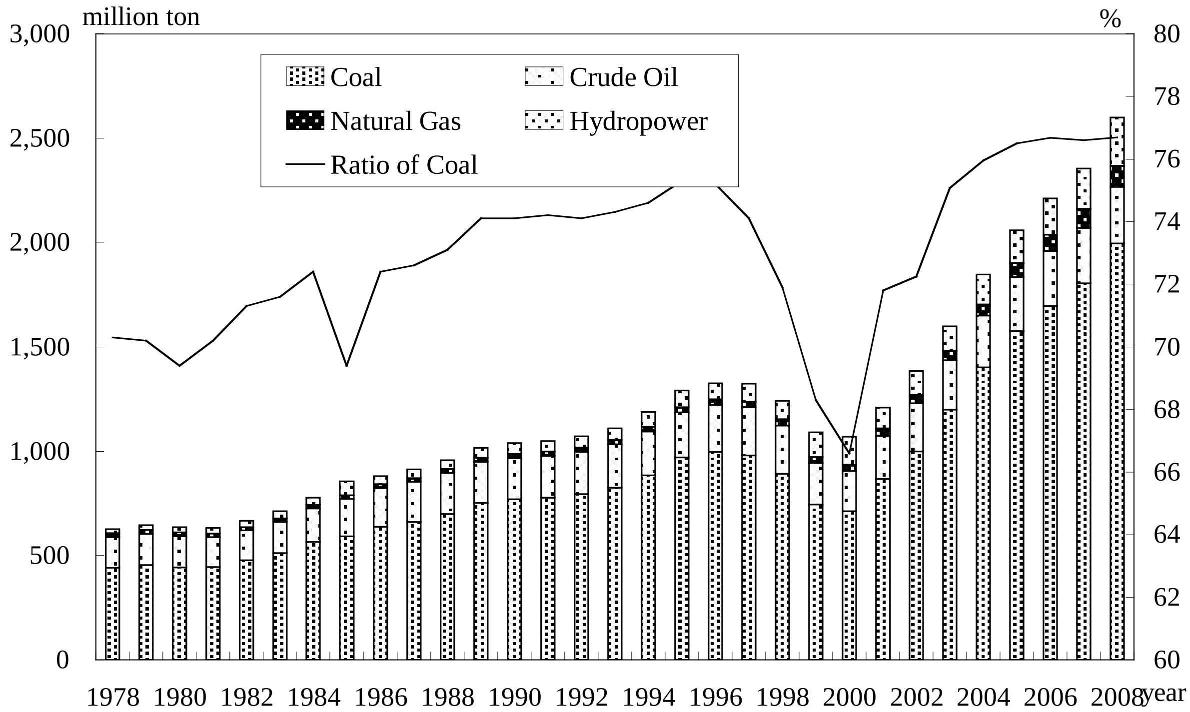
7 See the Agency for Natural Resources and Energy, Japan (2003).

Figure 1-1 World CO_2 emissions in 1990 and 2009



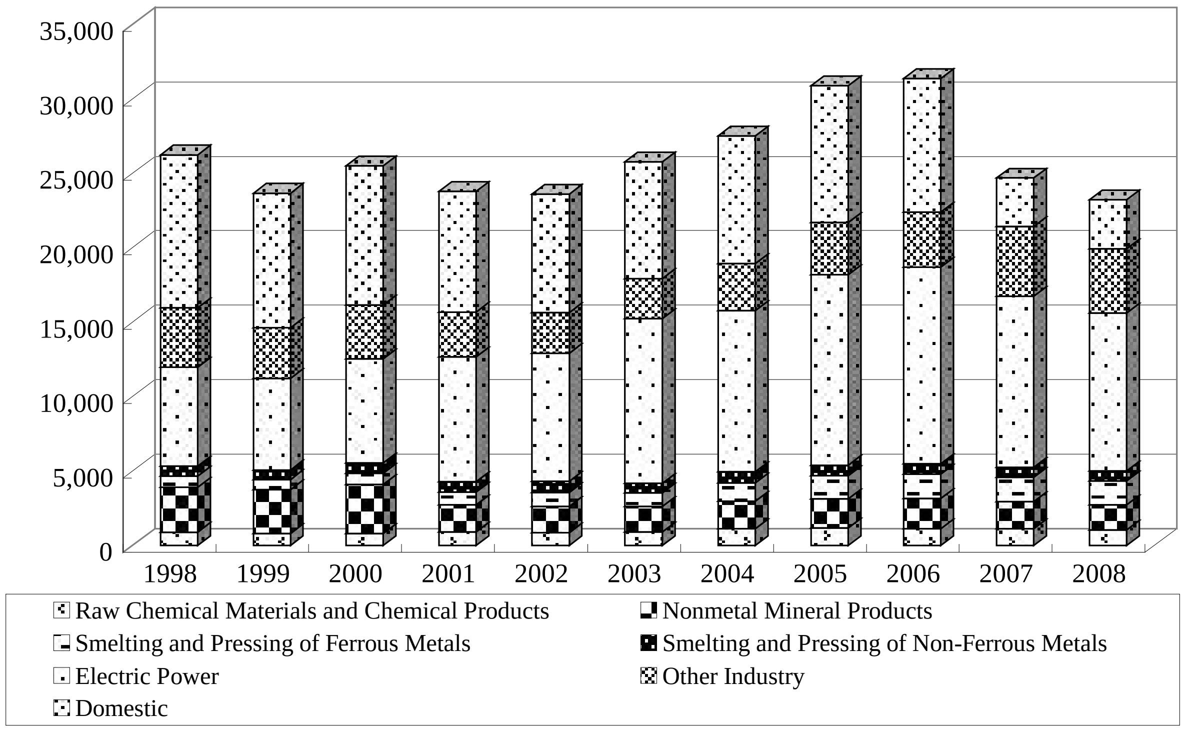
Data Source: Oak Ridge National Laboratory.

Figure 1-2 Development of energy production in China



Source: China Statistical Yearbook, various years.

Figure 1-3 SO_2 Emissions by sector (thousand tons)



Source: State Environmental Protection Administration of China, *Annual Statistic Report on Environment in China, 2002; 2004; 2006; 2008*.

Table 1-1 Number and capacity of thermal power plants by size

	1988			1998			2003			2008		
	Number	Capacity (thousand kW)	Share (%)	Number	Capacity (thousand kW)	Share (%)	Number	Capacity (thousand kW)	Share (%)	Number	Capacity (thousand kW)	Share (%)
Larger than 600MW	32	10,340	14.2	206	69,240	37.1	339	119,940	46.9	335	215,160	29.5
300-600MW										695	223,690	30.7
100-300MW	257	36,090	49.4	476	70,560	37.8	605	90,170	35.3	333	70,670	9.7
50-100MW	211	10,780	14.8	354	18,120	9.7	397	10,710	4.2	711	92,170	12.6
Less than 50MW	1,172	15,820	21.7	2,377	28,600	15.3	2,924	34,900	13.6	6,827	127,620	17.5
Sum	-	73,030	100.0	-	186,520	100.0	-	255,720	100.0	8,901	729,310	100.0

Source: Horii (2006) and Statistics and Information Department of the China Electricity Council (2009).

Table 1-2 Estimated economic damage by air pollution

Researcher	Year	Damage Cost (Nominal, RMB billion) Health	Acid rain	Total	% of GNP
Liu and Wang (1998)	1980	44.0	26.5		16.7
Guo and Chang (1990)	1983	38.0	49.8	124.0	15.6
Qu (1994)	1988	95.0	n.a		6.8
Smil (1996)	1988	43.7	124.8		9.5
Smil and Mao (1998)	1990	98.6	38.9	151.0	7.6
Sun (1997)	1992	26.0	17.9	60.5	2.3
Xia (1998)	1992	20.2	14.0	58.9	2.2
Xu (1998)	1993	13.8	16.0	39.1	1.1
Chinese Academy of Social Science (1998)	1993	7.8	28.9	46.0	1.3
China Environmental Yearbook (1997)	1995	12.0			1.7
World Bank (1997)	1995	352.5	41.4	407.2	7.1

Source: Lee (1999); Li and Warford et al., (2004).

Table 1-3 Plan and progress of total pollutants load control (thousand tons)

	1995 Actual	2000 Target	2000 Actual	2005 Target	2005 Actual	2010 Target	2008 Actual
Sulfer Dioxide	23,695	24,600	19,950	18,000	25,494	22,950	23,212
Industrial sector	18,460	22,000	16,125	14,500	18,914	-	19,914
Two control zones	-	-	13,160	10,530	-	-	-
Black smoke	17,436	17,500	11,650	10,485	11,825	-	9,016
Dust from industry	17,312	17,000	10,920	9,000	9,112	-	5,849

Source: SEPA Planning and Financial Bureau (2002), and National Bureau Statistics and Ministry of Environmental Protection (2009).

Table 1-4 Estimated contribution to sulfur deposition in Japan (%) (1990)

Model	Sources of Deposition			
	Japan	Volcanoes	China	Korean Peninsula
Ichikawa et al. (1995)	40	18	25	16
Ikeda et al. (1995)	37	28	25	10
Carmichael et al. (1995)	38	45	10	7
Huang et al. (1994)	94		3	2
Chinese Academy of Science (1995)	85		10	4
Calori et al. (2001)(note)	38	9	40	13

Note: This estimation is for the year 1995.

Source: Yamamoto (2008).